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ABSTRACT

The Bureau of Labor Statistics (BLS) projections of occupational employment growth have consistently underpredicted the growth of skilled occupations. BLS currently predicts that professional, technical, and managerial jobs will account for 40.9 percent of employment growth between 1990 and 2005. Forecasting regressions predict these occupations will account for 53 to 68 percent of employment growth through 2005. Between 1986 and 1991, these occupations accounted, in fact, for 64 percent of employment growth. The BLS's projections of the supply/demand balance for college graduates have also been off the mark--predicting a surplus for the 1980s, when, in fact, a shortage developed and relative wage ratios for college graduates rose to all time highs. A slowdown in the growth of college educated workers during the 1990s and a continuing escalation of wage premiums for college graduates are projected. The social returns to a college education are extremely high and are likely to go even higher. Public policy should not attempt to discourage the shift of students into engineering and business, since the market will be able to absorb even larger numbers of graduates in these areas without significant trouble. Public policy should facilitate this process by focusing special effort on improving mathematics, science, and economics instruction. In making occupational forecasts BLS should do the following: use data on trends in industry-specific occupational staffing ratios to extrapolate staffing pattern changes; be less judgmental in projecting staffing ratios; develop shorter (5-year) forecasts; and examine why forecasts were inaccurate. Presentation of projections should include the following: identification of methodological changes made; alternative scenarios; no listing of occupations with the largest forecasted growth; and information on growth in wages and employment in each occupation. (Contains 37 references.) (YLB)

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Is a Skills Shortage Coming? Review of BLS Occupational Projections

Working Paper 92–04

John Bishop

CAHRS Center for Advanced Human Resource Studies

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Draft

IS A SKILLS SHORTAGE COMING?
A REVIEW OF BLS OCCUPATIONAL PROJECTIONS
to 2005

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Working Paper # 92-04

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ABSTRACT

The Bureau of Labor Statistics projections of occupational employment growth have consistently underpredicted the growth of skilled occupations. BLS currently projects that professional, technical and managerial jobs will account for 40.9 percent of employment growth between 1990 and 2005. Forecasting regressions predict, to the contrary, that these occupations will account for 53 to 68 percent of employment growth through the year 2005. Between 1986 and 1991 these occupations, in fact, accounted for 64 percent of employment growth. The BLS's projections of the supply/demand balance for college graduates have also been off the mark--predicting a surplus for the 1980s when in fact a shortage developed and relative wage ratios for college graduates rose to all time highs. I project a slowdown in the growth of college educated workers during the 1990s and a continuing escalation of wage premiums for college graduates.

IS A SKILLS SHORTAGE COMING?
A REVIEW OF BLS OCCUPATIONAL PROJECTIONS TO 2005

Are we heading into an era of strong demand and insufficient supply of professional, technical and managerial workers combined with an oversupply of unskilled workers? If the Department of Labor sponsored Workforce 2000 report is to be believed, the answer is yes. Others disagree, however. Henry Levin and Russell Rumberger have stated:

> In summary, the evidence suggests that new technologies are unlikely to have a profound effect in upgrading the education and skill requirements of jobs, and that most new jobs or job openings will be in occupations that require relatively low skills and education (1987, p.344).

Lawrence Mishel and Ruy Teixeira predict:

> Far from an explosive growth of job skill requirements, the effect of occupational upgrading on job skills is actually projected to slow down in the future to one-third to one-fourth of its rate in the recent past. (1991, p. 1)

In 1990 the BLS projected the number of college graduates entering the labor force over the 1988-2000 period "to exceed the number of job openings in jobs requiring 4 or more years of college by an average of 150,000 annually" (Sargent and Pfleeger, 1990).

The issue under debate here is the skill and education requirements that are implied by a given occupational employment distribution, not the occupational employment distribution that is projected to prevail in the year 2000. Both Workforce 2000 and the statements quoted above are based on manipulations of BLS projections of occupational employment published in September 1987 and November 1989. Until now, participants in this debate have not questioned the BLS projections. In fact, some participants (those who do not work at the BLS) appear to put so much faith in these projections that they use verbs like "will" and "shall" when describing the year 2000 scenario projected by the BLS's computer.

This paper takes a look at these BLS projections and finds them wanting. In section 1 of the paper it is demonstrated that BLS projections have, in the past, systematically underpredicted the growth of occupations that require the

greatest amount of education and training. In section 2 the paper examines the latest data on occupational growth rates and concludes that the BLS's recent projections of occupational employment growth out to the year 2000 probably suffer from the same bias. A regression analysis of trends in occupational shares is conducted and the forecasts of occupational employment demand in the year 2005 based on these regressions imply substantially faster growth of higher level occupations than the BLS projects.

I then update Bishop and Carter's (1991) analysis of the supply/demand balance for college graduates by comparing past and projected percentage rates of change in employment in high skill jobs to actual and projected rates of change in the stock of well educated workers. The growth of professional, technical and managerial jobs as a share of total employment has been rapid and steady ever since 1960 and I project that the 1990s will probably see a continuation of these trends. However, rates of growth of the supply of college graduate workers have varied a great deal. High growth rates of supply generated falling college wage premiums. When growth of supply slowed dramatically during the 1980s, college wage premiums rose. The baby bust and the retirement from the labor force of the generation which benefitted from the GI Bill means that supply will grow in the 1990s even more slowly than in the 1980s. Consequently, I project that college wage premiums will continue to rise in the 1990s. This projection holds even if BLS projections of a slowdown in growth of demand for high skill occupations turns out to be correct.

The paper then turns to a discussion of policy implications. If the supply of college educated workers can not be expanded more rapidly than is projected (either through greater immigration of highly educated skilled workers or by increasing the number of Americans attending and graduating from college), wage premiums for college are likely to continue to grow. Shortages are particularly severe in business and technical fields and this has resulted in graduates of business and engineering programs receiving much higher wages than graduates who have majored in the humanities, education and social sciences other than economics. These wage differentials have helped induce a very rapid growth in

the numbers of students majoring in business and engineering. The wage advantage of graduates in engineering and physical science over those in the liberal arts has fallen a little from the peak reached in 1980, but it remains substantially above the premiums that prevailed during the 1960s. The paper concludes with recommendations for improvements in the way BLS makes and presents its occupational projections.

OCCUPATIONAL EMPLOYMENT PROJECTIONS FOR 1990

The Debate in the Early 1980s: The Bureau of Labor Statistics and Levin and Rumberger have been in the business of forecasting occupational employment growth for a number of years. What does the track record of their forecasts look like?

At the beginning of the 1980s there was a lively debate over the effects of technological change on skill demands and the likely supply demand balance for college graduates. The Education Commission of the States, for example, argued in 1982 that:

> Occupational growth throughout the 1980s is projected to expand most rapidly in the higher-skilled, technical occupations. Tomorrow's workers will likely need improved skills in the selection and communication of information. Many of today's skills considered to be of a "higher" level are the potential basic skills of tomorrow (quoted in Levin and Rumberger 1983, p. 2).

Basing their judgements on BLS projections published in August 1981, Henry Levin and Russell Rumberger argued to the contrary that:

> The expansion of the lowest skilled jobs in the American economy will vastly outstrip the growth of high technology ones; and the proliferation of high technology industries and their products is far more likely to reduce the skill requirements of jobs in the U.S. economy than to upgrade them (1983, p. i).

In February 1984, they said, "future job growth will favor service and clerical jobs that require little or no post-secondary schooling and that pay below-

average wages.(1984)"

Parallel disagreements existed over whether college graduates were likely to be in surplus or shortage during the 1980s. During the 1970s college graduates had been in excess supply and many graduates were apparently forced to take jobs in occupations that were not traditionally considered to require a college degree. The ratio of college graduate wages to high school graduate wages fell 11 percent between 1973 and 1979. The Bureau of Labor Statistics projected that this situation would continue in the 1980s. Testifying before the Senate Committee on Labor and Human Resources, Janet Norwood stated:

> College graduates entering the labor force through the 1980s are likely to face job market conditions very similar to those faced by graduates during the 1970s as entrants continued to exceed openings in jobs traditionally sought by graduates (1979).

In 1982 Jon Sargent predicted that "A surplus of between 2 and 3 million college graduates is expected to enter the labor force during the 1980s (1982, p. 7)."

On the other side of the issue was Richard Freeman, the economist who had been the first to call attention to the surplus of college graduates in the 1970s and the resulting declines of college wage premiums. In his 1976 book, The Overeducated American, he presented an empirical model of the college graduate labor market which predicted continued moderate declines of the college wage differential during the 1970s and an upswing during the 1980s. He reiterated this prediction in 1982:

> The most interesting prediction of the model--that of an increase in [the college] enrollments ratio, as well as in [college] salaries in the mid to late 1980s--cannot be examined at this time (Freeman and Hansen, 1983, p. 98).

The decade is over so it is now possible to settle these two controversies.

BLS Projections for 1980s: In August 1981, the BLS projected that professional, technical and managerial (PT&M) jobs, which were 24.9 percent of the nation's jobs in 1978, would account for 28 percent of employment growth between 1978 and 1990. Operatives, laborers, farm laborers and service workers

(OL&S) which were 37 percent of employment in 1978, were projected to account for 35.4 percent of employment growth during the period. Columns 4 and 6 of Table 1 tell us what actually happened. Professional, technical and managerial jobs accounted for 53.6 percent of 1978-90 job growth and operative, laborer and service jobs accounted for only 8.7 percent of the growth.

Table 2 compares projected and actual changes in occupational shares for nine major occupational categories. The biggest projection error was for managerial jobs. The projected slight decline in the managerial share became instead a 29 percent increase in the share from 9.73 percent to 12.58 percent. The Occupational Employment Survey (OES) yields an almost identical estimate of the growth of managerial employment and of the projection error. The error in projecting managerial employment was roughly equal to the total number of bachelors and masters degrees awarded in business, marketing and accounting between 1978 and 1990. The professional share of employment was projected to be stable; it grew by 17.8 percent resulting in an under-projection of 1.86 million jobs. If OES data is used, there is no forecast error for professional and technical jobs combined.

The operative and laborer share of employment was projected to fall only 5.2 percent; it fell instead by 23 percent, resulting in an overprediction of 3.8 million jobs. In OES data the drop is even more precipitous. The service worker share was projected to rise by 6.8 percent; instead, it remained stable resulting in an overprediction of 1.2 million jobs. Rates of growth for all low skill jobs combined--operatives, laborers, farm laborers and service workers--are identical in OES and CPS data so the conclusion that the 1981 projections significantly overpredicted the growth of low skill jobs is independent of the source of data on the growth of occupational employment.

For the 1982 to 1995 period, BLS projected that PT&M employment would account for 30.7 percent of employment growth and that OL&S would account for 30.8 percent of growth. Here again they appear to be far off the mark. For the 1982 to 1991 period PT&M accounted for 48.7 percent of job growth and OL&S accounted for 17.7 percent. (see row 5 of Table 1).

Table 1
Growth Shares of High and Low Skill Jobs:
BLS Projections Compared to Subsequent Changes

When Published	Projection Period	Share Prof, Tech & Manag. Projected	Share Prof, Tech & Manag. Actual	Share Oper, Lab. & Service Projected	Share Oper, Lab. & Service Actual
	1950-60	---	31.2%	---	27.7%
1969	1960-75	34.7%	37.3%	28.9%	23.1%
1971	1970-80	33.8%	38.1%	28.4%	20.1%
Bureau of Labor Statistics Changes Methods					
1981	**1978-90**	**28.0%**	**53.6%**	**35.4%**	**8.7%**
1983	1982-95	30.7%	48.7%*	30.8%	17.7%*
1985	1984-95	38.8%	55.4%*	28.7%	18.6%*
1987	1986-2000	37.9%	64.1%*	27.8%	19.7%*
1989	1988-2000	40.8%	95.4%*	24.6%	5.7%*
1991	1990-2005	40.9%	---	27.1%	---
Linear Regression Models of Occupational Shares	Jan 1992 1990-2005				
M1--Time, Unemp, Trade & PCShare		68.1%	---	0.3%	---
M2--Time, Unemp, & Trade		57.2%	---	10.6%	---
M3--Time & Unemp.		52.5%	---	6.1%	---

Source: The record of the 1960-75 and 1970-80 BLS projections of occupational shares and actual outcomes is taken from Carey (1980) and Carey and Kasunic (1982). Later projections come from Carey (1981); Silvestri, Lucasiewicz & Eckstein (1983); Silvestri and Lucasiewicz (1985, 1987, 1989, 1991) and are based on Occupational Employment Survey estimates of occupational shares in the initial year. CPS data on occupational employment from January issues of Employment and Earnings and Klein (1984) is used to estimate actual growth shares. Estimates of the level of high skill employment are higher in CPS data and this accounts for about 5 percentage points of the difference between projected and actual growth shares. For projection periods ending after 1990, an "actual" growth share (indicated by a *) is reported for the shorter period from the baseline year up to 1991. The "actual" high skill growth share for the 1988-91 period is temporarily extremely high (95.4%) because the recession has slowed the growth of low skill jobs like operative and laborer more than it has slowed the growth of professional and technical jobs.

Table 2

Percentage Changes in Employment Shares

	BLS 1978-90	Actual 1978-90	Projections 1990-2005 BLS	Bishop Model-1	Bishop Model-2
Managerial	-1.8%	21.3%	5.9%	26.9%	20.0%
Professional	2.3%	17.8%	10.1%	14.8%	12.5%
Technical	15.8%	25.4%	14.0%	26.3%	15.1%
Sales Occupations	3.1%	14.2%	3.5%	3.7%	4.3%
Administrative Support	.9%	-2.3%	-5.6%	3.2%	-1.3%
Craft	1.1%	-8.5%	-6.1%	-11.1%	-10.9%
Operatives & Labor	-5.2%	-23.0%	-13.5%	-29.7%	-20.2%
Service	6.8%	-.2%	7.6%	-3.1%	-0.5%
Farm	-35.5%	-25.3%	-13.0%	-34.8%	-26.5%

Just as one sided in its testimony on the issue is the recent behavior of occupational wage differentials. The wage premium that employers must pay for skilled workers tells us a lot about the demand/supply situation for skills. If demand for more skilled workers shifts out more rapidly than the supply, the relative wage of skilled workers will rise. And indeed, skilled workers have been getting higher real wages: the increase in real weekly earnings between 1983 and 1989 was 16.1 percent for technicians, 12 percent for professional workers, 1.5 percent for managers, 6.4 percent for sales representative selling commodities outside of retailing and 1.5 percent for sales representatives in finance and business services. If the demand for unskilled workers shifts out less rapidly than their supply, they will tend to suffer declines in relative wages. Between 1983 and 1989, a period of recovery from a deep recession, real weekly earnings of operators, fabricators and laborers declined 5.3 percent and the real weekly earnings of service workers declined 1.3 percent (Employment and Earnings, 1984, 1990). Real hourly wages of non-supervisory employees fell 8.1 percent in retailing and 4.4 percent in manufacturing.

Why were BLS Projections Biased?--BLS calculates its estimate of occupational employment demand by multiplying projected industry employment totals by an assumed industry specific occupational share vector. The BLS under-projected the growth of skilled jobs during the 1980s because it failed to predict the large decline in manufacturing employment and the substantial increase in the managerial and professional share of employment in many industries. The errors in projecting occupational shares were not just bad luck. They were an almost inevitable consequence of the method that the BLS started using in 1980 to make projections of future occupational shares for specific industries. The BLS makes its projections of future occupational shares by adjusting historical data on occupational shares. BLS conducts studies of the introduction of new technology and these studies often indicate that changes can be anticipated by the end of the forecast period. Since studies cannot be funded for every industry and for every technological innovation and the effects of these changes are very difficult to foresee 10 to 15 years in advance, many of

the changes that will occur in the composition of occupational demand within industry are missed by BLS projections.

BLS's forecasts of future staffing patterns must be extrapolated from Occupational Employment Survey (OES) data which is available only every three years and which has generally not been comparable from year to year. Complicating matters further was the change in the occupational classification system for the 1980 Census which was introduced into the CPS and the OES in 1982 and 1983. Given these data problems and the BLS's focus on projecting over 500 different occupations, it is easy to see why BLS has not chosen to systematically extrapolate past trends in occupational staffing ratios derived from OES or Census data into the future, but rather to rely on the judgement of analysts who can take data quality problems into account. However, systems which rely on the judgement of analysts are inherently conservative. Sometimes the analysts feel that they are knowledgeable enough about the situation in a particular industry to project substantial changes in staffing patterns. But forecasting big changes in staffing patterns is definitely perceived by them as "going out on a limb." The staff is small and they cannot be expert about all industries and occupations. As one analyst described the situation, "In a lot of cases, if we did not know a lot about the occupation, we just left it alone." These problems apparently still plague the projections published more recently.

An Evaluation of BLS Occupational Projections for 2005

The projections of occupational skill demands used by Workforce 2000, by Levin and Rumberger and by Sargent and other BLS authors are based on the same flawed methodology that failed to predict the strong growth of high skill occupations during the 1980s. It is, therefore, reasonable to hypothesize that the latest projections will understate upskilling trends of the 1990s.

One can see this unfolding in Table 1. The actual growth shares calculated for 1986 through 1991 may be compared to BLS's forecasted growth shares for 1986 to 2000 (see row 7). Since high skill jobs account for a larger proportion of total employment in CPS data than in the Occupational Employment Survey (OES) data used by the BLS, one needs to add 4 or 5 percentage points to the BLS

projected growth shares for high skill jobs to make them comparable to our CPS estimates of occupational growth. BLS projects that managerial, professional and technical jobs will account for 37.9 percent of job growth between 1986 and 2000. So far, however, the three high skill occupations have accounted for 64.1 percent of job growth between 1986 and 1991. In 1987, BLS projected that operative, laborer, farm laborer and service jobs would account for 27.8 percent of job growth between 1986 and 2000. So far, these low skill jobs have accounted for only 19.7 percent of job growth between 1986 and 1991.

Still another way to evaluate BLS projections is to compare their predictions to forecasts based on a regression analysis of changes in occupational employment shares during the 1972 to 1991 period. The source of the yearly data on occupational employment is the Current Population Survey. Consequently, the dependent variable is the share of workers who describe themselves as being in a given occupation not the share of jobs that employers describe as being in a particular occupation. The advantage of CPS data is that there is no double counting of workers with more than one job. For supply/demand comparisons CPS data has the further advantage of also being the source of data on educational attainment. This means that under enumeration of undocumented workers and homeless individuals has little effect on estimates of the balance between supply and demand because these individuals are excluded from both sides of the equation. The disadvantage of CPS data is the possibility that self reports of occupation are less accurate than data collected from employers.

Changes in occupational employment shares were assumed to follow a linear path. The variables that were found to have significant effects on occupational shares during the 1972 to 1991 period were: a simple trend, the unemployment rate, the merchandise trade surplus as a proportion of GNP, and the ratio of personal computers used in business to total employment. The personal computer variable captures the accelerated introduction of computer technology during the 1980s as well as the direct effects of microcomputers. Full details on model specification, the results obtained and how the projections were calculated is given in Appendix A.

In order to predict occupational shares for the year 2005, we must first project unemployment, the trade deficit and the ratio of microcomputers used by business to employment in the year 2005. Since the foreign debt of the US cannot grow at current rates indefinitely and the growing debt must eventually be serviced by exporting more goods than are imported, our projections assume that merchandise trade will be in balance in the year 2005. It was further assumed that unemployment will be 5.5 percent and the ratio of microcomputers to employment will increase from its 1989 level of 21 percent to 42 percent in 2005.

The results of these projections are summarized in rows 10 to 12 of Table 1 and columns 5 and 6 of Table 2. The preferred model which contains all four variables predicts that growth of managerial, professional and technical jobs will remain strong. These occupations are projected to account for 68 percent of growth of occupational demand between 1990 and 2005. Dropping the PC Share variable lowers the projected high skill share to 57 percent and dropping both the trade deficit and PC Share lowers it to 52.5 percent. BLS, by contrast, projects that the growth of managerial and professional jobs will slow and that these three occupations will account for only 40.9 percent of job growth. The regression models project declines in the employment share of craft workers, operatives and laborers and farmers and a stable share for service workers. Low skill jobs--operatives, laborers (farm and factory) and service workers--are projected to account for no more than about 10 percent of job growth to the year 2005. BLS, by contrast, projects that 27 percent of job growth will be in these low skill occupations.

It is also useful to contrast the actual percentage changes in occupational shares reported in columns 2 of Table 2 with the changes projected for 1990 to 2005 presented in columns 3 to 5. The regression models predict that the rapid growth of high skill occupations that prevailed in the 1980s will continue in the 1990s. BLS projects that the upskilling trend will suddenly decelerate.

BLS Projections of Supply/Demand Balance for College Graduate Workers

What about The Bureau of Labor Statistics' 1980 forecasts of a continuing

surplus of college graduates? It is extre emely difficult to make accurate forecasts of rates of change of the supply de mand balance for college educated labor; much more difficult than projecting occu upational employment alone. Small errors in forecasting rates of change of deman d or supply can translate into big errors in projecting the gap between supply a nd demand.

Despite the difficulties, BLS has been p ublishing biannual projections of the supply demand balance for the past two de cades. The starting point of its projections are its forecasts of occupation nal employment growth. It then projects changes in the proportion of partic ular occupations that "require a college degree", the number of bachelors degre ees to be awarded per year and the annual rates of flow into and out of jobs b y workers with a college degree. Comparisons are then made between the projected number of job openings "requiring a college degree" and the projected flow of college graduates seeking work (Sargent and Pfleeger, 1990). The record of these projections is presented in column 3 of Table 3.

Quite clearly the BLS effort to proje ct the supply/demand balance for college graduates has been a failure. Such a judgement is possible, because changes in the ratio of young college grad uate wages to young high school graduate wages over the projection period p provide an ex post criterion for evaluating the accuracy of the projections o f supply/demand balance. At the beginning of the 1970s, BLS projected rough ba alance of supply and demand during the subsequent decade. If the projection had been correct, the relative wage of college graduates should have been stable d uring the period as indicated by column 4 of the table. In fact, however, the supply of college graduates grew more rapidly than demand and, as a result, the college/high school wage ratio for workers with 1 to 5 years of post-school work experience fell 6.7-7.6 percentage points by 1980 (see column 5) (Katz and Murphy , 1990). At the end of the 1970s, BLS projected very large surpluses of colleg e graduates during the subsequent decade. According to their projection, the surplus of college graduates was going to grow at a rate equal to 30 percent of the annual flow of bachelors degrees awarded. If the projections had been correct, the surplus should have

Table 3
BLS Projections of the Supply/Demand for College Graduates
and
Subsequent Changes in the College Wage Premium

When Published	Projection Period	Projected Avg. Annual Surplus (in 1,000's)	Implied Chg. in CG/HS Wage Ratio	Actual Chg. in CG/HS Wage Ratio
1970	1968-80	8	Stability	- 6.7%
1972	1970-80	20	Stability	- 7.6%
1974	1972-85	62	Stable/Decline	+14.2%
1976	1974-85	86	Stable/Decline	+18.9%
1978	1976-85	300	Big Decline	+23.2%
1980	1978-90	275	Big Decline	+26.5%
1982	1980-90	300	Big Decline	+23.6%
1984	1982-95	300	Big Decline	
1986	1984-95	200	Decline	
1988	1986-2000	100	Small Decline	
1990	1988-2000	150	Decline	

Source: The record of past BLS forecasts of the supply demand balance is from an unpublished BLS memorandum. The data on subsequent changes in the ratio of college and high school wages for workers with 1 to 5 years of experience is from Lawrence Katz and Kevin Murphy, "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," 1990, which is to published in the Quarterly Journal of Economics next year.

caused the relative wage of college graduates to fall during the subsequent decade. In fact, however, increased demand for college graduates substantially outstripped increased supply and the college/high school wage ratio for those with 1-5 years of experience rose by 23 to 26 percentage points to all time highs. Thus, the projections were much worse than uncorrelated with the truth, they were negatively correlated with the truth.

The problems are much deeper than simple errors in forecasting future occupational employment levels. The description of the present and recent past is wrong as well. It is stated, for example, that 27 percent (6,659,000) of college graduates were "underemployed" in 1988 and that "underemployment" increased by 1,655,000 between 1983 and 1988. Clearly, a measure of "underemployment" for a group that increases simultaneously with the group's relative wage is seriously flawed. One of the problems with the approach is the lack of symmetry in the handling of possible mismatches between educational qualifications and occupation. Workers whose education appears to leave them under qualified to perform their job are not characterized as "undereducated." By ruling out the possibility of undereducation, the conceptual framework makes a conclusion that there are too many college graduates inevitable.

The task that BLS has set for itself--measuring the level and forecasting changes in the absolute number of jobs which "require a college degree"--is just about impossible. The classification of occupations into a "requires a college degree" category is inherently arbitrary and idiosyncratic to the analyst; yet the validity of the whole effort to measure "underemployment" depends on this classification being done correctly in every detail not only for the present but also for ten years in the future. This is impossible for four reasons. First, the occupational coding system used by the CPS and the Census is not reliable and comprehensive enough to allow accurate measurement of a concept like underemployment. Many of the apparent mismatches between occupation and education are the result of errors in reporting occupation. Census Bureau studies have found that between 18.3 and 27.3 percent of the individuals recorded as professionals, technicians or managers in one interview, are recorded in an

entirely different major occupational category in a subsequent interview 4 to 7 months later (U. S Bureau of the Census 1972).

Second, there are also substantial errors in measuring educational attainment. Between 5.5 and 9 percent of respondents who are recorded to have more than 16 years of schooling in one interview are recorded as having fewer than 16 years of schooling in a later interview (U. S. Bureau of the Census, 1972). Still another problem arises from the fact that about 11 percent of those who tell Census interviewers that they have completed 16 years of schooling also report that they do not have a bachelors or higher degree (Adkins 1975, and U.S. Bureau of the Census 1987).

The third problem is that for most occupations, the question "Does it require a college degree?" does not have a yes or no answer. Its a matter of degree. Some employers structure their management jobs in ways that make the skills normally developed in college absolutely essential, at other employers the skills are very helpful, and at still others the skills are of little advantage. The magnitude of the college graduate productivity advantage also depends on the quality of the alternative labor supply. If the competence of those who ended their schooling with high school deteriorates (as it did during the 1970s), the demand for college graduates will increase. The correct answer to the question of whether a college degree is required is, "It depends." It depends on circumstances that analysts and researchers have little knowledge of and no ability to forecast a decade ahead.

The fourth problem is the great heterogeneity of the college graduate category. A psychologist recently asked a community college student who wants to become a teacher, "How many weeks in a year?" She replied "Hmmm.., there are 365 days in a year. I don't know! Oh I'll just double it...730." This student is no doubt an extreme case, but not as extreme as one would like. More than 40 percent of young adults with Associates and/or Bachelors degrees cannot calculate change from a menu. Seventeen percent of young college graduates read at a level below the typical 11th grader (Kirsch and Jungeblut, 1986, p. 33, 37 & 40). How can someone with an 11th grade reading level be considered underemployed in

a secretarial, a carpentry or retail sales job? We conclude that the BLS method of evaluating the balance between supply and demand of college graduates is a blind alley.

If something useful is to be said about the balance between supply and demand, one must put both price and quantity data to work and give up on the idea of measuring how many people are "underemployed."

A Framework for Interpreting Data on the Supply/Demand Balance

The approach taken here is simply to compare percentage changes in supply and demand over time and interpret these changes in the light of contemporaneous shifts in the wage premium for college. Changes in the employment of college graduates can be decomposed into two components: (1) shifts that can be explained by changes in the occupational composition of employment and (2) changes in college graduate share of individual occupations. The growth of the engineering profession from 0.13 percent of the workforce in 1900 to 1.6 percent of the workforce in 1988 is an example of the first source of change. When one projects future occupational employment, one is effectively also projecting this source of change in the demand for college graduates. Historical rates of growth of occupational demand for college graduates are given in the first two rows of Table 4, an updated version of a table in Bishop and Carter 1991. The second row of the table contains rate of change data for an index of occupational demand for college graduates that was calculated by multiplying employment in each major occupational group in year t by the 1988 proportion of workers in that occupation group who had a college education and then summing across occupational groups.

The third and fourth rows of table 4 present data on annual rates of change for the supply of college educated workers. Rates of change for the difference between ex post supply and ex post occupational demand are given in the fifth and sixth rows of the table. The normal state of affairs is for college graduate supply to increase more rapidly than an index driven by shifts in occupational employment shares and for the difference to be made up by increases in skill and educational requirements of specific jobs.

Table 4
Growth Rates of College Graduate Demand, Supply and College Wage Premiums

	1950-60	1960-70[a]	1972-80[a]	1980-88	Projected 1988-2000 Bishop	Projected 1988-2000 BLS
Demand						
Prof, Tech, Manager & Sales Rep Emp	2.69	3.00	3.92	3.45	2.49	1.7
Occup. Demand for College Graduates[d]	2.29	2.93	3.43	2.89	2.14	1.6
Supply						
College Graduate LF (16+ yrs Sch)	4.96	4.34	6.22	3.76[f]	2.8	2.8
College Educated LF (13+ yrs Sch)	4.30	4.62	6.11	3.63	2.6	2.6
Supply minus Demand						
CG Supply/ Prof, Tech, Man & SRep	2.27	1.34	2.30	.31	.31	1.1
CG Sup/ CG Occup. Demand	2.67	1.41	2.79	.87	.66	1.2
College/ HS Wage Ratio						
All Exp. Levels	?	1.1[b]	-1.4[b]	1.5[b]	?	?
1-5 Years Experience	1.2[c]	0.5[c]	-.9[b]	2.8[b]	?	?
Relative College Supply/ Relative Occ. Demand						
CG Occ Dem/ LE High School Occ Dem[e]	.66	1.58	1.54	1.52	1.46	0.61
Coll Grad Supply/ LE HighSchool Sup.	3.06	3.53	4.88	3.51	2.8	2.8
CG Supply/ LE High School Supply / CG Occ Dem/ LE High School Occ Dem	2.40	1.95	3.34	2.00	1.34	2.19

[a] Data sources are not comparable before and after 1972 because of changes in occupational coding and because prior to 1972 data on the educational breakdown of the workforce is for individuals above age 18 rather than for those over 16 as in the period after 1972.

[b] Annual rates of change in the college/ high school wage ratio are for 1963 to 1971, 1971 to 1979 and 1979 to 1987. Lawrence Katz and Kevin Murphy, "Changes in Relative Wages, 1963-1987," 1990, forthcoming Quarterly Journal of Economics.

[c] Annual rates of change for the ratio of yearly earnings of 25-34 year old white male college graduates to 20-29 year old white male high school graduates from Census data. Dieter Marenbach, "Rates of Return to Education in the United States from 1939 to 1959." Stanford University Doctoral Dissertation, University Microfilms, 1973, p. 89-90 and 1970 Census.

[d] Occupational demand for college graduates index was calculated by multiplying the proportion of the occupation that had a college degree in 1988 by the actual or projected number of employees in each occupation and summing across occupations.

[e] Relative college graduate occupational demand was calculated by dividing the occupational demand index for college graduates by a similarly defined occupational demand index for workers with 12 or fewer years of schooling.

[f] The 4.18 percent per year growth of workers reporting college degree to CPS interviewers has been lowered to 3.76 percent per year because over reporting of educational attainment went up substantially during the period. See ftnote 1.

Source: Occupational employment data is from Historical Statistics of the U.S., D184, D185 & D859-D870 and from Deborah Pisetzner Klein, Employment and Earnings, Jan. 1984 & Jan 1990. Data on the educational breakdown of the Labor force is from Handbook of Labor Statistics, Table 65, 1982 and from the 1950 Census, Special Report on Occupation, Table 11.

Engineers work at a knowledge frontier that has been shifting out at an extraordinary pace during the twentieth century. Consequently, the skills and training required to perform satisfactorily in this occupations have increased. At the beginning of the century most engineers did not have a bachelors degree; now a bachelors degree is required of just about all new entrants and 20 percent of engineers have a masters degree. This demand driven escalation of the educational requirements for being an engineer illustrates the primary reason why college graduate shares of many occupations have increased over time.

This is not, however, the only reason why the share of college graduates in an occupation might increase. During a period when college graduates are in abundant supply, some college graduates may find themselves forced into lower paying occupations which are thought to not require the skills developed in college. The signal that this is happening is declining wage premiums for recent college graduates. If, on the other hand, wage premiums for college graduates and professional occupations are stable or growing at the same time as the share of college graduates in specific occupations is rising, it is reasonable to infer that an outward shift of demand within occupations not an increase in supply caused the increase. Rows 7 and 8 of the table provide the data on annual rates of change in the college/high school wage ratio that is essential for interpreting changes in the supply minus occupational demand index reported in rows 5 and 6.

Interpreting the Past

During the 1960s the relative wage of college graduates rose, even though managerial, professional, technical and sales representative and manager (MPT&SR) jobs grew 1.4 percent per year more slowly than the number of college graduates in the labor force. This means there was an exogenous outward shift in demand for college graduates holding occupation constant of substantially more than 1.4 percent per year during this period. Despite the rise in their relative cost, firms tended to expect new hires to have more schooling than had been expected in previous decades.

The leading edge of the baby boom ge neration graduated from college in 1970. The Vietnam War induced a large s hare of this generation to attend college, and the result was that the number of college graduate workers grew at a 6.22 percent annual rate during the 1970s. . The number of workers with 12 or fewer years of schooling grew as well so the ratio of college graduate supply to non-college supply grew at a rate of 4.88 p ercent per year (see row 10). The number of college graduate workers grew 2.8 p ercent (see row 6) more rapidly than the college graduate demand index and relati ve supply of college graduates grew 3.34 percent (see row 11) more rapidly th an relative occupational demand. Exogenous demand driven increases in the col llege graduate shares of particular occupations were not sufficient to make up p this gap. A surplus of college graduates developed, wage premiums for colleg ge and professional occupations fell and some graduates were forced into lower le evel occupations.

During the 1980s, the number of colleg ge graduates in the labor force grew 2.46 percent per year more slowly than in th he 1970s.[1] Growth rates of relative college graduate supply were 1.37 percent pe er year below their level during the 1970s (see row 10) while relative occupati ional demand for college graduates continued to expand at the rates that preva ailed during the 1970s. This meant that college graduate supply was growing onl ly 0.3 to .9 percent faster than the occupational composition demand indexes. Exogenous increases in demand for college graduates within occupations must h ave been quite strong, for the wage premium for recent college graduates increas ed 2.8 percent per year between 1979 and 1987 and the premium for all graduates r ose 1.5 percent per year. The first eight years of the 1980s were clearly a peri iod of a growing shortage of college graduates.

Projecting the Future

I project that percentage growth rate s of the supply of college graduates will be smaller during the twelve year pe riod beginning in 1988 than in the previous decade. The November 1991 Projectio ns of Education Statistics forecasts that the average annual number of BAs awarded during the 1990s will be 1,080,000.

This is an 8 percent increase from the NCES projections made just one year earlier in 1990. Nevertheless, this forecast implies that annual percentage rates of growth in the supply of college graduates will be .86 percentage points lower than in the 1980s.[2] This decline in the growth of college graduate supply is caused by three phenomena: falling achievement levels and high non-completion rates in American high schools, the projected decline in the size of the 20-30 year old age cohort which accounts for most students receiving BAs and the growing number of college educated workers reaching retirement age during the 1990s.

When the preferred model is used, the growth of demand is also projected to slow, but only by 0.75 percent per year. In other words, the tendency during the 1980s of demand for college graduates to grow more rapidly than supply is projected to become somewhat stronger. If demand projections are based on regression model #2 or #3, the balance between supply and demand growth that prevailed in the 1980s is projected to continue and college wage premiums are projected to continue to grow. The BLS projections imply a major reduction in the growth of occupational demand for college graduates relative to those with 12 or fewer years of schooling. The slowdown in the growth of supply is also very substantial, however, so the BLS projections imply a supply-demand balance very similar to the balance that prevailed during the 1960s a period of slowly rising college wage premiums.

Thus, the regression models and even the BLS projections imply a further widening of the gap between the wages of professional and managerial workers and the wages of non-supervisory employees. Early evidence does not contradict this prediction. Real wages of non-supervisory workers fell 3.3 percent between the first quarter of 1989 and the first quarter of 1991 while the median earnings of managers rose 1.2 percent and the median earnings of professionals fell only 1.5 percent (Employment and Earnings, 1989, 1991).

The Growing Demand for Graduates Trained in Business and Technical Fields

The shortage appears to be particularly acute for college graduates in

business, technical and scientific fields. Evidence of this shortage is provided by the very large salary premiums commanded by graduates who have majored in physical science, engineering and business. The first four columns of Table 5 present data from the College Placement Council on how field of study effected the starting salaries received by college graduates whose placement outcomes were reported to the school's placement office for 1963, for 1969-70, for 1979-80 and for 1991 (College Placement Council 1985; 1991). The differences across field are sometimes as large as the wage gains accruing to those obtaining higher level degrees. Relative to majors in humanities and social sciences other than economics, engineers received 45-70 percent higher starting salaries in 1991, computer scientists received a 38 percent premium, physical science majors received a 24 percent premium and business majors received a 10 percent premium. Studies of the earnings of adults indicate that the salaries of business majors tend to catch up with the engineers, but education and liberal arts majors remain far behind those with engineering, physical science and business degrees (see column 5 and 6).

Largely because of these large wage differentials, there has been a dramatic growth in the relative supply of graduates in engineering, computer science and business administration. For males degrees in engineering, computer science and business which accounted for 33.2 percent of all BA's in 1973 rose to 50.8 percent of all bachelors degrees in 1986. For women degrees in engineering, computer science and business grew from 3.5 percent to 26.6 percent of degrees awarded. In 1973 degrees in education, humanities and social science accounted for 50.5 percent of bachelors degrees awarded to men and 83.5 percent of the bachelors degrees awarded to women. By 1986 these percentages had dropped to 35.1 percent and 54.7 percent respectively. As a result, the ratio of degrees awarded in engineering and computer science to degrees awarded in humanities, social science or education grew 5.2 percent per year in the 1970s and 10.7 percent per year in the 1980s. The ratio of business degrees to humanities, social science, and education degrees grew 5.8 percent per year in the 1970s and 5.1 percent in the 1980s.

Table 5
Wage Premiums by College Major
(Relative to Bachelors Degree in Humanities)

	Starting Salaries[a] Year				Median Earnings Males age 21-70 BAs in 1966[b]	Average Monthly Earnings in 1984[c]
	1963	1969-70	1979-80	1991		
BAs in Low Wage Major						
Humanities	0	0	0	0	0	0
Social Sciences					14%	---
Economics	--	--	8%	15%	--	111%
Other Social Sciences	0	0	-1%	-3%	--	28%
Education	--	--	--	-13%	-9%	-6%
Biological Sciences	--	--	--	-1%	-11%	12%
Agriculture	--	--	--	4%	--	45%
Health	--	--	--	39%	--	12%
Bachelors in High Wage Major						
Physical Science	17%	17%	36%	24%	28%	93%
Mathematics	18%	15%	36%	24%	--	68%
Engineering					52%	114%
Chemical Eng.	23%	28%	67%	70%	--	--
Electrical Eng.	27%	24%	56%	50%	--	--
Industrial Eng.	20%	21%	53%	45%	--	—
Mechanical Eng.	24%	23%	57%	54%	--	--
Computer Science	--	--	44%	38%	--	--
Business					28%	103%
Accounting	10%	17%	21%	21%	--	--
Other Business	0	2%	11%	10%	--	--

[a] Percentage differential between the starting salary in the designated major over that received by humanities majors. The College Placement Council "Inflation and the College Graduate" 1985 and CPC Salary Survey, Sept. 1991.

[b] Percentage differential for median yearly earnings of males whose highest degree is a BA or BS in the designated major relative to median earnings of humanities majors. Current Population Reports, P-20, No. 201.

[c] Percentage differential for mean monthly earnings of men and women whose highest degree is a BA or BS in the designated major relative to earnings of humanities and liberal arts majors. Current Population Reports, P-70, No. 11, p. 13.

The very rapid growth during the last 20 years of the relative supply of college graduates trained in business and engineering fields has surprisingly not significantly diminished the wage premiums these fields command. Trends in starting wage premiums for business and technical degrees can be followed by comparing the first four columns of Table 5. Relative to humanities majors, wage premiums for engineering degrees grew dramatically during the 1970s and then dropped slightly by 1991, but remained significantly above the levels that had prevailed in the 1960s. Wage premiums for chemistry and mathematics majors over humanities majors rose from 17 percent in the 1960s to 36 percent in 1979-80 and then fell to 24 percent in 1991. Starting wage premiums for business majors rose from essentially zero in the 1960s to 10-11 percent during the late 1970s and 1980s.

Trends in the effect of college major on salaries of college graduates who have been working for many years can be examined by comparing columns 5 and 6. In 1967 male college graduates 21-70 years old who had majored in business earned 28 percent more and engineers 52 percent more than those who had majored in humanities (U.S Bureau of the Census, 1967). In 1964 college graduates (male and female) who had majored in physical science earned 93 percent more, engineers earned 114 percent more and business majors 103 percent more than humanities majors (U.S. Bureau of the Census, 1987). Clearly, the economic payoff to business and technical education is considerably greater than the payoff to majors in the humanities and social sciences other than economics and the advantage of these fields of study has not diminished appreciably in the face of the massive increase in the number of students choosing these fields of study. Clearly, there has been a substantial shift in market demand favoring graduates with business and technical degrees over graduates with liberal arts and education degrees. In addition, tne most important externalities of university education--technological advances--are generated by the education of scientists and engineers.

Policy Implications of the Skills Shortage

For policy, what matters is (1) the balance between current supply and current demand as indicated by the magnitude of the college wage premium, (2) the balance between forecasted growth of supply and forecasted growth of demand and (3) the magnitude of the changes in wage premiums necessary to bring ex ante differences in supply and demand into ex post equilibrium. Let us begin by examining the current balance between supply and demand. The wage premiums for obtaining a college degree grew substantially during the 1980s and are now at historic highs. This implies that either the demand for college graduates grew more rapidly than supply or the demand for high school graduates grew much less rapidly than their supply. Either way, social rates of return to a college education have seldom been higher. This implies that public policies which increase college attendance and completion (eg. better academic preparation in high school, low tuition at state colleges and larger grants for needy students) now yield larger benefits than ever before.

Possible Market Responses to the Skill Shortage

Demand for college graduates grew more rapidly than supply in the 1980s and this situation is projected to continue in the 1990s. College attendance and graduation rates have risen recently in no small measure due to the strong market for college graduates. The ratio of bachelors degrees awarded to population 18 to 24 years of age rose a remarkable 29 percent between 1980 and 1990 and NCES now projects a further 10 percent increase in this ratio. Even much larger responses to the improved incentives would not change the basic situation; a 15-20 percent increase rather than a 10 percent increase in college graduation rates, for example, would raise the number of college graduates by only 50,000 to 100,000 annually and reduce the number of workers with 12 or fewer years of schooling by a similar amount.

Another possible natural market response to the strong demand for college graduates is further increases in labor force participation rates. The participation rate of male college graduates 25 to 54 years old was 96.7 percent

in 1988, so there is not much room for an increase. Participation rates for female college graduates 25 to 54 years old were 81.5 percent so significant increases in labor supply are possible here. A five percent increase in labor force participation rates of women with a college degree would increase the supply of college graduate labor by 850,000 in the year 2000 (an increment of 106,000 per year between 1992 and 2000). Still another way to increase labor supply is to postpone retirement. In 1988 labor force participation rates for 60-64 year old college graduates were 65 percent for males and 46 percent for females. Phasing in a two year increase in the age at which all college graduates retire would have the same impact as an 81,000 increase in the annual number of BAs awarded between 1992 and 2000. Even if all three of these possibilities became reality by the year 2000 (and there is no guarantee that any of these responses will occur), the college graduate wage premium would not collapse.

Possible Policy Responses

The social returns to a college education are extremely high and are likely to go even higher. Supply responses to the strong market do not appear to be sufficient to prevent a continuation of the current escalation of college wage premiums. If wage premiums for college educated workers continue to escalate, inequality will continue to grow, American corporations will be at a competitive disadvantage and multinational corporations will probably transfer offshore functions which intensively employ college graduates such as research, product development, design and marketing. Hewlett-Packard recently announced, for example, the relocation of the headquarters of its personal computer division from the United States to Grenoble, France. The resulting escalation of wage premiums for professional and managerial workers will probably slow down the growth of these occupations and our projections may well not be realized. Absent a policy response to stimulate the supply of college graduates, difficulties in recruiting high skill workers will force the economy off the upskilling path generated by the growth scenarios we have simulated and the rapid upskilling of

the 1970s and 1980s may slow considerably.

Education is a public function and a pub olic policy response to the shortage appears to be in order. Cost effective w ways of stimulating a substantial increase in the supply of college graduates a are needed. Probably the most cost effective way of ameliorating the shortage is to change immigration policy. There is a long queue of university graduates (many already fluent in English and some with degrees from American universities)) seeking permanent residence in the United States and it only requires a change i in immigration policy to double the number of college educated immigrants to 200 ,000 a year. If total immigration were held constant, the supply of workers with h limited amounts of education would be reduced simultaneously.

The number of American born college e graduates can be increased by strengthening academic standards in high s chools, by reducing the very high dropout rates in American colleges, by encou uraging adults to return to college to complete their degree, by keeping public t uition levels low and by shortening the time required to get a degree by expand ling Advanced Placement programs in high schools and encouraging college studen ts to take courses during summers. The "increase the home grown supply" appro ach has two advantages: (1) since college training occurs in the US, it w will probably be adapted to the requirements of American jobs and (2) the number of unskilled workers is decreased at the same time as the number of skilled workers is increased.

It would appear that the market will be able to absorb even larger numbers of graduates in business and engineering witho out significant trouble. Therefore, public policy should not attempt to discou urage this shift of students into business and engineering and should, in fact, facilitate it by focussing special effort on improving math, science and econ omics instruction in the hopes of increasing the pool of students entering s scientific, technical and business careers.

Recommendations for Changes in BLS Projectio on Methodology

Recent BLS occupational projections ha ve been systematically biased. The occupations that BLS forecasts will grow more e rapidly do indeed grow faster than

other occupations, but the forecasts systematically underpredict the growth of high skill occupations and overpredict the growth of low skill occupations.

I recommend, therefore, four changes in the way BLS makes occupational forecasts. First, BLS should develop data on trends in industry specific occupational staffing ratios for all industries and all occupations by making fuller use of the 1970, 1980 and 1990 Censuses and the OES surveys. It should then use these data to extrapolate changes in staffing patterns into the future. The null hypothesis should be that past trends in occupational staffing ratios will continue in the future unless information is available to the contrary. In other words, we are recommending a return to the occupational projection methodology employed in 1969 and 1971 to forecast 1975 and 1980 occupational employment (see Tomorrow's Manpower Needs: Vol. III, p. 4 for a description). Forecasts should also be developed using regression models similar to those estimated here and comparisons made to forecasts based on the full industry requirements model.

Second, the process of projecting occupational staffing ratios needs to become less judgmental. A system needs to be developed and documented that makes projecting big changes automatic if powerful trends are visible in time series data. Analysts should not be made to feel that projecting a big change puts them "out on a limb." Documentation is essential because one cannot learn from experience if experience is not documented in a way that one can figure out 5 or 10 years later why the projections were made the way they were. Documentation is also required if scholars outside BLS are to review its procedures.

Third, forecasts for five years ahead need to be developed and published along with the longer term forecasts. A shorter forecast horizon means that analysts will learn from their forecast errors more quickly and corrections to the forecasting model can be made in a more timely manner.

Fourth, more research is needed of why forecasts of occupational growth during the 1980s were so far off the mark. While the unforecasted decline of manufacturing is part of the problem, systematic errors in forecasting staffing patterns were its primary cause.

I also recommend four changes in the way projections are presented. First, future BLS presentations of occupational forecasts and supply/demand projections should point out that past forecasts of occupational growth have understated the growth of skilled occupations relative to unskilled occupations. The reader should be told what changes have been made in projection methodologies to correct the problem and a judgement should be offered as to whether the changes in methods are likely to correct the problem.

Second, in order to inform users of the sensitivity of predictions to the assumptions used to generate forecasts, alternative scenarios regarding the introduction and effects of new technology and the growth of foreign trade should be developed (either in-house or by contracting with outside organizations) and their impacts on forecasts of occupational demand should be described in the articles reporting new occupational forecasts. The current caveats which warn the reader that forecasts are often wrong is not sufficient. The only way to ensure that users are aware of the uncertainties is to publish the consequences of scenarios which differ greatly in their underlying assumptions.

Third, future articles should not contain a special table listing the occupations with the largest absolute forecasted growth. Which occupations show up in this table depends on arbitrary decisions regarding the degree of occupational detail that Census and BLS choose to use in their coding scheme. Since the occupational coding schemes used have less detail at the bottom of the skill distribution, these tables give the misleading impression that low skill jobs are growing rapidly even when they are a shrinking share of total employment.

Fourth, BLS publications aimed at guidance counselors should provide information on recent rates of growth for wage rates and for employment for each occupation discussed as well as projections of future employment growth. Changes in relative wages are not only important in their own right, they are generally also good signals of demand and supply conditions for an occupation.

APPENDIX A

The growth of occupational employment shares was assumed to follow a linear trend. In our preferred model, the "j"th occupation's share of employment in year t, S_{jt}, is assumed to depend on the year (T_t), the unemployment rate (U_t), and one or more structural variables, (X_t), intended to capture the influence of the economic changes that have occurred in the 1980s. The independent variables have been defined relative to their projected value in the year 2000.

1) $S_{jt} = a_0 + a_1(T_t - 2005) + a_2(U_t - .055) + a_3(X_t - X_{2005}) \quad t = 1972...1989$

For the farm occupational category, X_t is a trend shift variable for the years after 1980. For the other occupations the X variables were the ratio of the merchandise trade surplus to GNP, ($TRASUR_t$), and the ratio of personal computers used in business to civilian employment, ($PCUSE_t$).[3] The advantage of deviating all independent variables from their projected level in the year 2005 is that the intercept term, a_0, then provides an estimate of the forecast of the "j"th occupation's share of employment in the year 2005.[4]

The estimation results for the 9 occupational categories are presented in Table A1. T statistics are located in parenthesis under the coefficient.

Managers, professionals, technicians and clerical workers have large positive coefficients on the trend variable. The occupational shares of sales workers and service workers have been growing but only very slowly. Shares for craft workers were pretty stable through 1980. The shares of all other occupations fell. Declines were quite rapid for operatives, laborers and farmers.

The employment shares of craft, operative and laborer occupations rise strongly during booms and decline during recessions. A one percentage point rise in unemployment decreases the operative/laborer share of total employment by 2.7 percent, the craft share by .9 percent and the managerial share by .7 percent.

Professionals, technicians, sales workers, service workers and farm workers gain in share of total employment during recessions.

Trade deficits reduce the occupational share of operatives/laborers, clerical workers and technicians and increase the shares of sales workers, craft workers and service workers. The coefficients on the merchandise trade surplus imply that the switch from a merchandise trade surplus of 0.7 percent of GNP in 1976 to a trade deficit of 3.6 percent of GNP in 1987 decreased operative/laborer employment shares by 8 percent, increased precision production and craft employment shares by 5 percent and increased sales worker shares by 8 percent. The business press appears to have been correct when, in the face of rising aggregate employment of managers, it pointed to losses of managerial jobs resulting from the recession and the loss of international competitiveness and the strong dollar. Compared to the cutbacks in factory operative jobs, however, the resulting managerial layoffs were modest indeed. Since the overall upward trend of the managerial employment is so strong (1.5 percent per year in 1989), these setbacks turned out to be temporary. Almost all of the growth of managerial jobs has been outside of manufacturing.

The effects of the microcomputer revolution and the associated reorganization of manufacturing were tested by including the ratio of personal computers used in business to civilian employment, ($PCUSE_t$), in the preferred model for most occupations. The microcomputer revolution appears to have had a substantial negative effect on the employment share of technicians, clerical workers and craft workers. The results imply that the rise in PCUSE from zero in 1978 to 18 percent in 1988 lowered technician and craft employment by 5.6 percent and technician and clerical employment by 7.6 percent. These machines have resulted in a large decline in the demand for board drafters and have improved labor

productivity in a host of other technical and clerical occupations. Electrical and electronic technicians and health technicians both of which grew at a torrid 7.2 percent per year between 1972 and 1982, slowed to yearly rates of only 0.5 and 3.1 percent respectively between 1982 and 1989. The occupations that gained share as a result of the microcomputer revolution were professionals, sales and service occupations. Employment in sales grew more rapidly in the 1980s than in the 1970s largely because of the trade deficit and increased use of microcomputers.

Farm workers were best represented by a simpler model which simply allowed for a trend shift in 1980 capturing a slowdown in their rate of decline.

Projections: What do these estimation results tell us about the future? This, of course depends on future levels of unemployment, the trade deficit and PC use. Since the foreign debt of the US cannot grow at current rates indefinitely and the growing debt must eventually be serviced by exporting more goods than are imported, our projections assume that merchandise trade will be in balance in the year 2000. It was further assumed that unemployment will be 5.5 percent and PCUSE will increase from its 1988 level of 18 percent to 42 percent in 2005. The intercept terms of the equations provide an estimate of the forecasted share, S_{i2005}, for the year 2005. Projected growth rates of occupational shares may be calculated by dividing the intercept by the share that prevailed in 1990 which is given in the final column of the table.

We forecast strong increases in demand for managers, professionals, and technicians and absolute declines in the number of craft workers, farm owners and workers and semi and unskilled blue collar workers. Sales, clerical and service jobs are projected to grow at approximately the same rate as total employment so their share of total employment should be relatively stable.

Table A1
Determinants of Occupational Employment Shares for 1972-1991
Linear Model #1

	Trend	Unemp	Merchandise Trade Surplus	PC Use	Trend GT 80	Intercept[a] Shr in 2005	MSE	R^2	Share in 1990
Managers	.207***	-8.44**	7.49	.80		16.09***	.127	.992	12.58
	(9.92)	(2.68)	(1.57)	(.73)		(13.20)			
Professionals	.112***	16.94***	.21	2.56***		15.52***	.078	.994	13.41
	(8.78)	(8.78)	(.07)	(3.82)		(12.94)			
Technicians	.069***	2.37*	4.68**	-1.03**		4.15***	.049	.978	3.26
	(8.55)	(1.94)	(2.52)	(2.41)		(8.64)			
Sales	.035	9.89**	-23.36***	2.75**		12.59*	.139	.965	12.04
	(1.53)	(2.86)	(4.45)	(2.28)		(1.91)			
Clerical	.103***	-1.33	13.98**	-6.68***		16.45*	.169	.744	15.81
	(3.72)	(.31)	(2.20)	(4.58)		(1.80)			
Craft & Prec. Production	-.024	-10.87***	-13.19**	-3.58***		10.37***	.132	.916	11.57
	(1.09)	(3.31)	(2.65)	(3.13)		(4.34)			
Operatives & Laborers	-.294***	-40.11***	27.20**	-2.66		10.68***	.247	.990	15.07
	(7.22)	(6.54)	(2.92)	(1.25)		(8.47)			
Service	-.043**	17.54***	-10.45***	3.15***		13.06	.093	.844	13.37
	(2.81)	(7.56)	(2.97)	(3.91)		(1.56)			
Farm	-.141***	7.45***			.076***	1.90***	.055	.992	2.89
	(20.56)	(6.52)			(7.09)	(11.12)			

* Prob. LT .05 (two tail test)
** Prob. LT .025 (two tail test)
*** Prob. LT .01 (two tail test)

[a] The coefficient on the intercept term provides an estimate of the occupation's share of total employment projected for 2005. The T test on the intercept term evaluates the hypothesis that the projected share in 2005 is different from the share in 1990.

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ENDNOTES

1. Comparisons of CPS estimates of increases in the number of college graduates in the population to estimates derived from data on bachelors degrees awarded for period prior to 1980 suggest rough consistency. During the 1980s, these two data sources diverge. The number of individuals born after 1935 claiming to have completed 16+ years of schooling increased by 9,181,000 between 1980 and 1988. During this eight year period, there were only 6,543,000 bachelors degrees awarded in the US. Immigration probably accounts for another 734,000 of this increase and individuals with 16+ years of schooling but no degree for another 1,019,000. This leaves a remaining discrepancy of 885,000 that is probably increased misreporting of years of schooling. This means that the true growth rate of college graduate workers is not the 4.18 percent per year figure calculated directly from CPS data, but rather 3.76 percent per year that results from subtracting 885,000 from 26,814,000, the 1988 CPS estimate of the number of college graduate workers, when calculating the rate of gain between 1980 and 1988. This correction of the data helps explain why the college graduate labor market tightened so dramatically during the 1980s. It also results in the 1990s looking more like the 1980s and thus reduces our estimates of the magnitude of the shortage during the 1990s.

2. The no policy change projection of the increase in the stock of workers with 16 or more years of schooling was developed in the following manner. The National Center of Educational Statistics projects that an average of 1,080,000 BAs will be awarded each year during the 1990s, an 11.5 percent increase from the level that prevailed from 1980 to 1988 (Projections of Education Statistics to 2002, Table 200). Immigration of people with a college degree was about 100,000 per year in the first part of the 1980s (data provided by George Borjas) and this flow is assumed to increase to 120,000 becuase of the 1991 Immigration Act. Adkins reports that for every 100 individuals with a BA degree there are about 12.5 individuals reporting 16 or more years of schooling without having a BA or first professional degree. This information is from Douglas L. Adkins, (1975). Therefore, our estimate of the flow into the college graduate category is obtained by multiplying 1.18 million by 1.125. The share of the flow of new college graduates assumed to be employed was set equal to the labor force participation rate for this group, .90. The result was a projection of 14,349,000 individuals added to the stock of employed college graduates over the 12 year period. In the March 1988 CPS, there were 3,018,000 college graduates over the age of 65, 3,245,000 between 55 and 64 and 4,982,000 between 45 and 54 years of age. Their labor force participation rates were .906 for 45-54 year olds, .706 for 55-64 year olds and .222 for those 65 and over. (Bureau of Labor Statistics, "Educational Attainment of Workers: March 1988" July 1988). Based on life tables, the estimated 10 year survival rate is .9083 for the 45-54 year old college graduates and .8136 for the 55-64 year old group. (Statistical Abstract, 1990). An estimate

of the number of college graduates from the 45-64 year old group in 1988 that are still in the labor force 10 years later was obtained by multiplying the population figures by the survival rate and then by the labor force participation rate for the next older group. Exits from the labor force for the 12 year period were estimated to be 1,585,000 of the age 45-54 in 1988 group, 1,729,000 in the 55-64 in 1988 group and 670,000 (all) of those over 65 in 1988. Thus, the projected net growth in the number of college graduates over the 12 year period is 10,365,000 from a 25,929,000 level in 1988 or 2.8 percent per year. BLS's 1990 prediction of the growth of college graduate workers is substantially lower--9,105,000 (BLS, "1988-2000 Outlook for College Graduates, unpublished technical memorandum, 1990). The 1991 NCES projections of supply growth are used in column 5 and 6 of Table 4.

3. The estimates of the number of PCs in use in business were made by Future Computing/Datapro Inc. and were published in 1990 by the Bureau of the Census in the Statistical Abstract, (943-952). They are derived by cumulating numbers of machines sold. A very low scrap rate of 3.4 to 6 percent depending on the year was assumed. Where possible vendor reports were used to allocate sales of computers between categories of end user--business, education and home. Quite often, however, rules of thumb were used to make these allocations. Future Computing is no longer in business so more detailed information on how the series was constructed and data for 1989 are not available. Point estimates of PCs in use were made for 1989-91 and for 1979-80 by extrapolation.

4. A number of alternative models were estimated in order to see how sensitive the results are to changes in functional form, specification and in the scenario projected for the year 2005. Such tests were needed because there were only 18 years of data on which to estimate the forecasting model and theory did not yield only one plausible specification. The results of some of these tests are detailed in Bishop and Carter (1990). While specification and scenario do effect projected occupational shares, all of the specifications yielded substantially larger increases in skilled jobs than the BLS projections. Other findings were robust with respect to specification and scenario as well.